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Original Article

DEVELOPING PRESERVICE SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE USING CORES-BASED ACTIVITY

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ABSTRACT

Pedagogical content knowledge (PCK) was one of teacher professional knowledge to teaching to enhancing student understanding, therefore, teachers needed to improve their PCK to improving teaching practices. This research aimed to explore and develop preservice science teachers' PCK for science teaching using Content representations (CoRes)-based activities. Research participants were 13 Thai preservice science teachers. Magnusson et al. (1999)'s PCK conceptualization for science teaching was employed as a theoretical framework for data collection and data analysis. CoRes proposed by Loughran et al. (2004) and modified Lesson Planning document was applied as the research methodology in this workshop. Data were collected and analyzed from preservice science teachers' CoRes and Lesson Planning documents as well as Focus group discussions and interviews. These research results showed that in the beginning preservice science teachers mostly had the inadequate content knowledge, knowledge of science curriculum and knowledge of instructional strategies for teaching science. As a consequence, preservice science teachers developed their knowledge of instructional strategies and students' understanding of science from lesson preparation through CoRes-based activities. In summary, CoRes-based activity workshop can be used to examine and promote the development of preservice science teachers' PCK for teaching science and also engaged them to realize about how to teach for student understanding.

KEYWORDS: Preservice Science Teacher, Pedagogical Content Knowledge & Content Representations

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INTRODUCTION

Pedagogical content knowledge (PCK) proposed by Shuman (1986) is one of teacher professional knowledge bases that teachers possess for teaching particular content to particular students for enhancing student understanding (Berry, Friedrichsen, & Loughran, 2015). Teachers with adequate PCK can employ effective instructions to deliver content knowledge in a way to enhance students' meaningful learning. Teachers develop their professional knowledge of teaching from their teaching experiences over time, while novice teachers and preservice teachers might struggle with their limited teaching experience and need support to develop their teaching practices (Aydin et al., 2013; Hume & Berry, 2013). Five-year teacher education programs in Thailand, preservice teachers are required to experience in teaching for one academic year in school, so they need to possessing adequate teacher professional knowledge and developing their teaching practices for a short time. Therefore, an effective procedure is very important to supporting student teachers' development of PCK even though they already had studied about teaching and learning from teaching method courses of teacher education program (Kind, 2009). Teacher education programs should emphasize and incorporate PCK conceptualization into

teacher education program for enhancing preservice teachers' professional knowledge for teaching. In the context of teacher education, PCK can be promoted by explicit introduction of PCK in teaching courses and specific research methodology such as Content Representations (CoRes), and Pedagogical and Professional-experience Repertoires (PaP-eRs) to support student teachers' professional learning (Hume & Berry, 2011; Loughran, Mulhall, & Berry, 2008).

PCK is used as a conceptual framework for exploring and enhancing science teachers' professional knowledge for teaching in various science education researches. The widely adopted PCK conceptualization for science teaching was proposed by Magnusson et al. (1999) compose of five components including: orientation to teaching science, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of assessment of science learning, and knowledge of instructional strategies for teaching science, respectively (Magnusson, Krajcik, & Borko, 1999). Because of complexity and complicated nature of PCK that difficult to understand and display to others, thus researcher needs to develop research methodology to disclose and get insights into teachers' PCK. Loughran et al. (2004) developed research instrument called Content Representations (CoRes) to capturing and recording teachers' PCK for teaching particular science topic for students' understanding that successfully applied into many educational research (Berry et al., 2015; Loughran, Mulhall, & Berry, 2004). Furthermore, Hume and Berry (2011) reported that construction of CoRes activity in science teaching course can be supported preservice science teachers to develop their professional knowledge for teaching and CoRes construction was recommended as a useful tool for lesson preparation. Finally, this study aimed to enhance the development of preservice science teachers' PCK for science teaching through CoRes-based activity in Thai context.

METHODS

Research participants were 13 preservice science teachers (PSTs) from the department of General Science, Faculty of Education, Phuket Rajabhat University (PKRU), Thailand. General Science PKRU five-years teacher preparation-program consisted of 4-years coursework and 1-year teaching experience in school. In the science teaching courses, teacher students were occasionally studied about PCK for science teaching and employed their teacher professional knowledge in their teaching experiences in school (Berry, Friedrichsen, & Loughran, 2015). This study was conducted in first semester of 5^{th} -year preservice science teachers at the beginning of their school practicum.

This study applied Magnusson's (1999) PCK model for science teaching as concept framework for data collection and data analysis(Magnusson, Krajcik, & Borko, 1999). Content Representations (CoRes) was modified and used to capture and portray PSTs' PCK in lesson preparation. CoRes provided a set of science concepts for teaching particular science content called 'Big Idea' at the top of the column, and a set of pedagogical questions called 'CoRe prompt' in the left-hand column of the table (Table 1). PST created CoRes and then completed the related lesson plans as Lesson Planning documents that further collected and analyzed of their PCK. Lesson Planning documents were designed and modified from traditional lesson plan focusing on eliciting teacher's PCK for science teaching.

PSTs' perception of PCK and ideas from their teaching practices were collected from the pre-workshop interview. Furthermore, PST's view on CoRes-based activity workshop was collected from Focus group discussion and post-workshop interview. Data analysis used content analysis and cross-case analysis methods to categorize and interpret data of PSTs' PCK for science teaching throughout the workshop. Workshop activities and data interpretation were developed with suggestions from three experts of science teacher education as Peer debrief method to ensuring Credibility (Internal validity) of this research (Cohen, Manion, & Morrison, 2011).

Table 1: CoRes Modified from the originally Proposed by Loughran et al. (Loughran et al., 2004)

Content Area/Unit: For Teaching Student Grade	Important Science Concepts (Big Idea)		
	Big Idea/ Topic. 1	Big Idea/ Topic. 2	Big Idea/ Topic. 3
1. What students have to learn about this topic?			
2. Why is it important for students to understand this topic?			
3. What else do you know about this topic (that you do not want students to know in this section)?			
4. What are the difficulties/limitations related to teaching this topic?			
5. What is your knowledge about students' thinking, which influences their understanding of this topic?			
6. Are there any other factors that influence your teaching of this topic?			
7. What are your teaching methods (focusing on how to engage the student to understand this topic)?			
8. Methods for checking students' understanding about this topic (Including students' responses).			

In CoRes-based activity workshop, PSTs used CoRes for teaching particular science content for their students' understanding. First, an introduction of PCK and CoRes activity, researcher and PSTs discussed Big Idea and pedagogical questions (CoRe prompts) and how CoRes related to science teaching. PSTs consequently created Big Ideas for teaching science topic that they would be taught in their actual classrooms and then wrote Lesson Planning documents for their teachings. In the third activity called teaching preparation activity, PSTs created CoRes and related Lesson Planning documents for their teaching practices. After completed CoRes and Lesson Planning documents, PSTs presented their teaching plans to researcher and colleagues for sharing ideas and finding the resolution in teaching presentation activity. Consequently, PSTs studied the example of inquiry-based learning activity as well as how to assessing student's Science learning that provided the alternative ideas for PCK-based science teaching and learning. The last step of CoRes-based activity workshop called Developing lesson planning activity was the presentation of Re-write PSTs' lesson planning and Focus group activities.

Table 2: Details of CoRes-based Activity Workshop Activity

No.	Workshop Activity	Research Instruments
1.	Introduction of PCK and CoRes activity	1) Pre-workshop interview 2) Focus group discussion
2.	Big Ideas creation activity	CoRe constructions
3.	Teaching preparation activity	CoRe constructions and Lesson planning documents
4.	Teaching presentation activity	Focus group discussion
5.	Developing lesson planning activity	1) Lesson planning documents 2) Focus group discussion 3) Post-workshop interview

PSTs were asked for their initial opinions on CoRes construction as the pre-workshop interview in Focus group discussion. Post-workshop interviews were individually conducted after group discussion about how to enact CoRes and Lesson Planning documents into classroom practice. Data were collected from CoRes, Lesson Planning documents,

interview transcripts, and researcher's field notes. In data analysis, Magnusson's (1999) PCK model for science teaching was used as the conceptual framework in Content analysis method.

RESULTS

Preservice science teachers completed CoRes for their own teaching and described their ideas for teaching to answering CoRe prompts in many ways. PSTs mostly created the similar pattern of teaching procedure and assessment method however they teaching in different topics and student grades. Teaching preparation and Focus group activities also represented that PSTs had inadequate PCK in some aspects including; First, from the Big Ideas creation and teaching procedures to answering CoRe prompt no. 7 (What are your teaching procedures?) PSTs mostly applied same learning activities such as do laboratory, question-answer and using learning media following teacher handbook. Additionally, from the pre-workshop interview they mentioned about the enactment of learning activities from school science textbook:

'I'm always looking for a set of questions-answer to ask students and key activity from (teacher) handbook.'

PST5, pre-workshop interview

'The first step to prepare my teaching is to find the activities or lab procedure in school textbook because it is the standard teaching method and I'm not sure to re-write lesson plan by myself'

PST3, pre-workshop interview

In addition, these results correlated to teaching methods in Lesson Planning documents that PSTs applied 5Es learning cycle approach to teaching all science concepts to all students group. In conclusions, these findings confirmed that preservice science teachers didn't have enough knowledge of instructional strategies for teaching science.

Secondly, in Big Ideas creation activity, PSTs struggled with the more complicated science concepts that related to Big Ideas. PSTs mostly created Big Ideas corresponding to science subunits in school science textbook rather than modified and rearranged scientific topics for students' understanding. PSTs created only two concepts (two Big Ideas) similar to subunits in school textbook for teaching in the topic of Cell that complicated and consisted of many topics (Table 3). PSTs should start with the probing students' prior knowledge and then introduced a concept of the microscope as well as added the topics of discovery of cell, cell type and differentiated cell for the specific function to support students' understanding.

Table 3: Big ideas Creation for Teaching in the Topic of Cell Created by Preservice Science Teacher

Content Area: Cell For Teaching Student Grade: 7th year	
Big Ideas no.	**Science Concept**
No. 1	Study of the cell by using the microscope
No. 2	Cell and structure of cell
No. 3	Organelles and functions

In addition, pre-workshop interviews revealed to PSTs' inadequate content knowledge. For instance, some of PST could not be simplified and rearranged science concepts to support their students' understanding.

'I think the most difficult part is to create Big Ideas because I'm not sure how to make these concepts to be easier for my students'

PST5, Focus group

'Sometimes I cannot understand these topics so I am not sure which concept I should teach before doing laboratory or put in the last because these concepts are all difficult, so I order science topics in the table (Big Ideas) similar to subunits in the textbook'

PST1, pre-workshop interview

Lastly, during Teaching preparation activity and focus group discussions PSTs occasionally used national science curriculum (Thai Basic Education Core Curriculum, B.E. 2551 (A.D. 2008)) to design important science concepts from Learning standards. Analysis of CoRes and Lesson Planning documents found that PSTs mostly followed the learning objectives and Grade-level indicators in teacher handbook and examples of school science lesson plans in the website. These data from discussions and interviews represented to the inadequate of knowledge of science curriculum that coherent with the learning objectives from Lesson Planning documents and CoRes from teaching presentations activity. These findings were consistent with data from interview including:

'…in the beginning, I read national curriculum for 2 or 3 times but I confused, so I always use science benchmarks in the first topic of each subunit in teacher handbook and then applied into lesson plan'

PST5, post-workshop interview

'I learned about how to create important science concepts and apply the Basic Education Core Curriculum in the lesson plan on the teaching course but I found it similar to teacher handbook and more convenient for me to write lesson plan'

PST10, group discussion

In summary, these research findings demonstrated that PSTs had inadequate PCK for science teaching as subject content knowledge, knowledge of science curriculum and knowledge of instructional strategies to teaching for student understanding.

The instances of possible PCK component were represented by interviews and focus group activities that supported with the edited CoRes and Lesson Planning documents. PSTs developed their knowledge of instructional strategies for teaching science and students' understanding of science through the creation of CoRes and modified learning activities for students' understanding. For example, from CoRe prompt no. 8 (assessment method) PSTs used the different methods to investigate students' prior knowledge and students' understanding such as classroom presentation, group work, student work etc. instead of pre-test and post-test examination that they mentioned in the pre-workshop interview. In addition, the findings from post-workshop interviews and PSTs' responses to CoRe prompt no. 5 (student's thinking and learning) and CoRe prompt no. 7 (What are your teaching procedures?) including:

'Because this topic may be too difficult for my student…so I cut off these too difficult questions and use the picture to explain. I think they (students) may get more understanding'

PST7, post-workshop interview

'I think rock cycle topics are very difficult and have a lot of information to remember…learning from school textbook maybe not enough, so I search animations and VDO clips from Youtube to explain each step of rock cycle to help them (students) to understand.'

PST2, post-workshop interview

'Hand-on activity for classifying rock type may help students to understand better than the typical instructions in the handbook and further provide the examples of soil for this lesson'

PST2, CoRe prompt no. 7

These findings correlated to data from CoRes and Lesson Planning documents that PSTs rearranged and applied different learning activities for their student's learning difficulties and school context in order to enhance students' understanding. From the Developing lesson planning and Focus group activities, PSTs mentioned that they checked the science learning indicators from National curriculum to find which level of content difficulties and rearrange science concepts for teaching their own students. In summary, data from the CoRes-based activity workshop were supported by the findings from CoRes and Lesson Planning documents that represented the development of preservice science teachers' PCK for science teaching.

DISCUSSIONS

Construction of CoRes with scaffoldings was the key activity for supporting the development of preservice science teachers' PCK for science teaching in this study. The results showed that PSTs unclearly perceived PCK from their disciplines to teaching science while one of the limiting factors to developing PSTs' PCK was their lack of classroom experience and supporting approach (Hume & Berry, 2011). PKRU teacher education programs rarely introduced the concept of PCK that contributed to the limited PSTs' professional knowledge for science teaching in this research, thus the developing and enhancing PCK in teacher education were necessary.

The requirement of developing PCK and applying PCK to support teacher professional knowledge for teaching was similar to the other studies in science teacher education institutions in Thailand (Buaraphan, Faikhamta, & Musikul, 2009; Wanaek, Naruemon, & Veerapaspong, 2013). Results from post-workshop interviews and Big Ideas creation were correlated to the data from CoRes and Lesson Planning documents that represented the development of PSTs' understanding and enactment of PCK in teaching preparations. In addition, CoRes-based activities also used to enhance PSTs' awareness of student's learning difficulties and students' understanding of science concepts in their lesson.

CONCLUSIONS

In summary, this research showed the effectiveness of PCK-based professional development programs that consistent to the other CoRes-based research methodology studies (Nilsson, 2008; Nilsson & Loughran, 2012) as well as other teacher preparation programs such as inquiry-based learning course of teaching courses and training program in Thailand (Nuangchalerm, 2012; Udomkun, Khaokhajorn, & Suwannoi, 2018). Thus, teacher educators and teacher education programs should promote teacher professional knowledge for teaching that preservice science teachers need to possess and apply PCK for science teaching into science teacher preparation programs. Research implications are given for teacher researchers and science educators to develop the effective approach to enhance science teachers' PCK and support their professional learning.

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